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VISION AND REGULATION OF THE GROWING COMMERCIAL SPACE TRANSPORTATION INDUSTRY

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The commercial space transportation industry is growing in size and diversity. New commercial ventures are in development for both orbital and suborbital launch vehicles in the United States. Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation are developing new expendable launch vehicles and spacecraft in partnership with the National Aeronautics and Space Administration (NASA). Suborbital companies including Masten Space Systems, Armadillo Aerospace, and XCOR Aerospace are advancing their vehicles through the NASA Flight Opportunities Program. Companies such as Scaled Composites, Blue Origin, and Bigelow Aerospace are testing concepts for space tourism and other purposes. As companies grow, some are looking outside the United States at potential sites for future operations that will further expand the market and encourage the growth of spaceports. XCOR Aerospace has been working with authorities in South Korea, Curaçao, and other countries while Virgin Galactic is considering operations from the United Arab Emirates and Sweden.

The Federal Aviation Administration (FAA) is evolving to accommodate the growing needs of the industry in both regulations and technology development. The FAA Office of Commercial Space Transportation (AST) is working with commercial launch operators to assist with regulatory compliance and ensure safe operations. In addition, AST has established a new Commercial Space Transportation Center of Excellence with several universities, for conducting research on human spaceflight, space vehicle standards, the development of new technologies, and other topics. A new FAA Commercial Spaceflight Technical Center has also been proposed. Primary focus areas of the center will be spaceflight safety, spaceflight engineering and standards, range operations, and space traffic management. AST is also working with other nations as they develop their own commercial space regulatory regimes in order to foster industry growth and support interoperability. This paper will discuss AST's vision for the near future, based on the industry's current plans and activities and developments in other countries.

I. INTRODUCTION

Before the early 1980s, there was no commercial space transportation industry. Only the United States launched commercial satellites, and these were launched on vehicles owned by the government, including the National Aeronautics and Space Administration (NASA) Space Shuttle. Events of the 1980s – including the birth of a European commercial launch services organization, recognition of commercial space transportation's value by U.S. government officials, and the ban of commercial payloads from flying aboard the Space Shuttle after the *Challenger* disaster – prompted the development of this industry in the United States. By the year 2002, U.S. commercial space transportation and the services and industries it enabled had grown and diversified to the point where they accounted for more than \$95 billion in economic activity, in addition to providing many benefits to public consumers; in 2009 that figure had increased to \$208 billion.¹ That level is likely to grow appreciably in the coming years as new players in the commercial space transportation market emerge. The space tourism market and NASA's future plans to use commercial providers for payload delivery to the International Space Station (ISS) and human spaceflight are going to provide a solid platform for the growth of the industry.

AST is the U.S. government organization responsible for ensuring public safety during commercial space launch and reentry operations, and facilitating and promoting international competitiveness of the U.S. commercial space transportation industry. This paper will discuss AST's regulatory vision for the near future of commercial space transportation, based on the industry's current plans and activities. Safety regulations for all of these activities must continue to evolve and improve so as to accommodate the growth and development of an innovative commercial space transportation industry, but not overburden it with regulations.

II. OFFICE OF COMMERCIAL SPACE TRANSPORTATION OVERVIEW AND REGULATIONS

The three sectors of the U.S. space program are civil, national security, and commercial. The regulation of commercial launch and reentry operations and the operation of launch and

reentry sites falls to the Department of Transportation (DOT)/FAA. At the same time, the Federal Communications Commission is responsible for the oversight of space communications, and the Department of Commerce's National Oceanic and Atmospheric Administration regulates commercial remote sensing.

The original 1984 Commercial Space Launch Act (CSLA, as amended) and Executive Order 12465 tasked the DOT with directives to encourage, facilitate, and promote the commercial space transportation industry, and to develop licensing requirements to regulate the industry's impact on public safety. In 2004 Congress passed the Commercial Space Launch Amendments Act (CSLAA)², giving the DOT the authority to regulate commercial human spaceflight and creating an experimental permit regulatory regime for the development of suborbital reusable launch vehicles. The CSLAA required that the human spaceflight regulations follow a phased approach, so as to allow for industry growth.

The FAA's statutory authority is codified in 51 United States Code Subtitle V, Chapter 509 and incorporated in AST's mission statement: to ensure the protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch and reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.³ The industry's growth, combined with its unblemished safety record, speaks to AST's success in executing this mission and the effectiveness of its approach to regulating this developing industry.

In the facilitation and promotion role, AST holds an annual conference every February, publishes forecasts, economic impact studies, year-in-review reports, and other industry reports. The office has held workshops, summits, and meetings with industry, national security, civil, and international partners in the interest of industry facilitation and support. The Commercial Space Transportation Advisory Committee holds twice yearly meetings to advise the Associate Administrator on industry thoughts, issues, and concerns. To encourage government use of commercial launch services, AST is involved in interagency policy development and monitors the impacts on U.S. commercial

companies. AST also envisions the possibility of safety agreements between governments, defining means for equivalent evaluations and regulatory compliance; this is one of the goals and focus areas of the AST International Outreach Program. Similar safety goals between nations would assist governments in vehicle assessments and acceptance, particularly in the case where one nation does not regulate an industry with existing commercial space vehicles.

III. LICENSING VERSUS CERTIFICATION

As the industry continues to grow and develop, AST must continue to evolve its regulatory approach. AST currently relies on the licensing and permitting of operations to ensure safety, but it may ultimately need to consider incorporating aspects of a certification process similar to that used in the aviation industry. The certification process for a commercial or general aviation aircraft requires that an applicant build their vehicle according to specific performance characteristics that are defined in the FAA regulations. Unlike the certification process that the FAA has in place for aircraft and rotorcraft, mandating vehicle design and characteristics, the commercial space transportation licensing regime focuses on the design and characteristics of the vehicle's operations.⁴ In many areas, these requirements are intentionally performance based, allowing applicants to demonstrate safety through a number of approaches rather than being forced to adhere to a single approach or a prescriptive design. While the AST licensing process incorporates time-honored best safety practices in the mitigation of hazards posed by an operation, this performance-based approach to regulation fosters an environment of innovation in which operators can develop their vehicles and mature enabling technologies that will continue to grow the commercial space industry.

A type certificate certifies that an aircraft design meets specified FAA safety standards, and airworthiness certificates certify that the specific aircraft conforms to the approved design. Meeting these design standards and receiving an FAA type certificate can be a lengthy process, on the order of years, determined by the requirements for test flights, engineering verification, and the workload of the Aircraft Certification Office (ACO) assigned with the project.⁵ The FAA licensing process for commercial space vehicles is purposely less time consuming. The CSLAA mandates a license

review process, during which time AST must work with the operator to determine their vehicle's hazards and perform an assessment of the risk the operations would pose to the public. After the operator's application is deemed complete enough, AST must make a license determination within 180 days. AST works with applicants prior to application submission to assist them in compiling sufficient data for a complete application, including an extensive environmental review. The licensing regime can be viewed as a stepping stone for future development of more comprehensive regulations if they are someday required.

This regulatory system was adopted in part to support the evolution of the commercial space transportation industry, which is extremely different from aviation in terms of flight profiles, loads, risks, and hazards. The costs associated with the development of the vehicles and fuels, as well as the challenges in testing and validating them typically exceeds aviation development costs. Combined with the fact that the market volume of customers is significantly smaller than the aviation community, the FAA is challenged with balancing regulations that will allow the industry to grow and innovate, without unnecessarily risking public safety.

AST's vision for supporting the growth of the commercial space transportation industry includes creating mechanisms to integrate human spaceflight regulations into current regulations, with industry support, to enable seamless airspace integration for operations, and enable productive international agreements to benefit commercial space transportation.

IV. COMMERCIAL SPACE TRANSPORTATION GROWTH

In the past, space-related activities were primarily supported by the United States government. More recently, the commercial space industry has been providing satellite launch services for other kinds of customers. AST licensed the first non-federal launch in 1989, followed in 1996 with the first launch site operator license. Since 2000, AST has responded to the industry's steady expansion into new vehicle and operations types with the development of new regulatory regimes and new programs. The first RLV license was issued in 2004, the first experimental permit was issued in 2006, and the first safety approval and the first

reentry license were issued in 2010. More recently, AST established the Spaceport Grant program to financially assist launch and reentry site operators with developing needed infrastructure and performing related studies, and the Commercial Space Transportation Center of Excellence as a partnership between government, industry, and academia to conduct critical research and the development of enabling technologies and approaches. Soon, the Commercial Spaceflight Technical Center will be opened to begin development of safety standards in the areas of human space flight, space traffic management, and range safety operations.

President Obama's budget requests and 2010 National Space Policy have put an emphasis on U.S. commercial space ventures to take over the traditional government role of ferrying payloads, and eventually people, to the International Space Station. Growth of commercial space transportation activities beyond the launch of satellites is evident in the United States today. These activities include:

- Contracts for U.S. commercial cargo resupply of the International Space Station
- Potential crew transfer missions to ISS
- Development of rendezvous and reentry capsules
- Privately operated orbiting habitats
- Development of suborbital launch vehicles for commercial human spaceflight
- Establishment of a technology center for commercial space transportation research
- Spaceport Grants
- Prize competitions.

Enabling commercial providers to transport cargo and crew to low earth orbit allows NASA to focus their efforts on the challenges of deep space exploration.

The industry has recently begun developing vehicles for commercial space tourism and experimentation platforms. Lately, there has been a surge of vehicles designed to be used repeatedly for particular missions. Spurred on by competitions like the Northrop Grumman Lunar Lander Challenge and events like the X-Prize Cup, small businesses like Masten Space Systems and Armadillo Aerospace have been awarded NASA contracts to take small payloads

into sub-orbital space to conduct science and demonstrate new technologies; however, there are even more ambitious projects in works. Companies such as Blue Origin, Virgin Galactic, and XCOR Aerospace have built business models around commercial suborbital space tourism, which could become a reality within the next few years. The latter two companies are developing RLVs designed to allow private individuals to experience suborbital space. To date, Virgin Galactic has collected deposits of more than \$40 million dollars from 440 participants, for \$200,000 flights into suborbital space⁶. Space tourism adds an entirely new dimension to the commercial space industry and presents a set of regulatory challenges that the FAA must accommodate. These challenges include the development of new approaches to the regulation of human spaceflight, the integration of new space vehicles into the increasingly crowded airspace system, the integration of new space vehicles into increasingly crowded orbits, and the establishment of international agreements to facilitate global operations.

V. HUMAN SPACE FLIGHT

In addition to the entrepreneurial interest in developing space tourism, NASA's pursuit of commercial crew transportation is jump starting the commercial orbital human flight sector. The expected growth is going to require the FAA to review and reassess human space flight regulations currently in place. The CSLAA, passed in 2004, gave the FAA the authority to regulate human space flight through an informed consent regime, but starting in December of 2012, AST will be able to propose regulations that are designed to ensure the safety of people flying onboard these vehicles. Currently, AST is in the very early stages of developing a potential regulatory approach for commercial human space flight, but we recognize that coordination with NASA, input from the industry, as well as continued internal efforts will all be needed in order to make sure that any new requirements are appropriate.

As one considers the human space flight regulatory regime, it is important to understand that there are key differences between the missions of the FAA and NASA. For commercial crew, NASA can be considered to be the customer, which means that they could have detailed requirements that would drive the

vehicle design and mission success criteria. As a regulatory body, the FAA only focuses on safety. This approach will allow the FAA to put forth performance based requirements that will hopefully enable the industry to innovate and develop. As a result, future human space flight regulations will likely be focused on safety and *not* on mission assurance; for example, there may be a minimum set of core requirements intended to assure the safety of those onboard the vehicle. The regulations will need to be technically sound, verifiable, and attainable. The FAA is working with NASA to assure that its future regulations and the potentially more prescriptive NASA requirements are compatible. This will be very important in order to minimize the burden on the industry.

The FAA plans to evaluate its regulatory requirements to the human space flight system as a whole; they will need to cover the launch vehicle, crewed element, and portions of the ground segment. The core design requirements may set minimum values to address cabin safety, system reliability, and human factors. In addition to the minimum requirements, the processes put in place may require applicants to use a system safety process to assess risk and perform hazard analyses, use human integration processes to manage capabilities and limitations, validate and verify requirements, and maintain a “spaceworthy” system. This paper will not address these future requirements in detail, as the specifics of each will need to be further discussed with the appropriate stakeholders.

VI. SPACE TRAFFIC MANAGEMENT

Another critical element to cooperation between nations and interoperability is consistent air and space traffic management. Space vehicle traffic within and above the airspace must be safely and efficiently integrated with the traffic of other airspace users. Launch and reentry vehicles can present hazards to other airspace users beyond those traditionally considered and addressed through air traffic control. The FAA’s approaches to addressing these hazards must properly consider their impacts on the already-constrained domestic and international airspace systems.

The FAA has supported over 20 Space Shuttle launches since the 2003 *Columbia* accident. The *Columbia* Accident Investigation Board recommended that NASA work with the FAA to

develop and implement airspace protection measures in the case of another orbiter reentry breakup. The lessons learned from developing the appropriate tools and working with air traffic controllers and other agencies have allowed AST to mitigate potential hazards to aircraft during reusable launch vehicle (RLV) and reentry vehicle flights.

In order to keep the National Airspace System (NAS) functioning effectively during launches and reentries of experimental space vehicles, optimized flight restrictions are currently used to preemptively clear airspace, thereby reducing hazards to aircraft. At the same time, AST is developing a concept of operations based on its approach to Shuttle reentries. This concept calls for a dynamic and responsive approach to airspace protection that will leave airspace open beneath an operational vehicle as it transits through and above the system. The extensiveness of preemptive airspace closures would otherwise cause an unacceptable impact to airspace capacity and efficiency.

The FAA is working to develop integrated air and space traffic management tools that can work in the domestic and oceanic realms. These tools will provide dynamic airspace management to support of suborbital RLV flights, and eventual point-to-point international flights. The FAA ultimately hopes that space vehicle flights will not require flight restrictions, but fully rely on real-time surveillance and automated traffic control tools that can notify controllers and pilots if a hazard is presented, while immediately calculating response maneuvers and mitigation actions. Developing next generation tools will help the FAA track and monitor vehicles that perform beyond radar tracking abilities. In coordination with space situational awareness, the traffic management system may grow from the domestic realm to a system supportive of input from numerous nations, air and space bound entities, and various vehicle types.

VII. ON-ORBIT OPERATIONS

Many industry watchers consider suborbital human spaceflight to be the stepping stone to orbital missions, crewed space complexes, and commercial experiment platforms in Low Earth Orbit. Currently, international treaties mandate that space be used for peaceful purposes, and nations are expected to conduct operations in a

responsible manner. Questions surround the legality of vertical airspace limitations, over-flight rules, and operations on-orbit. The operators of all visiting vehicles to the International Space Station abide by rules for proximity operations that mitigate hazards to the humans onboard.

With new entrants in the orbital commercial human spaceflight market, such as Bigelow Aerospace, the questions surrounding on-orbit operations and responsibility continue to abound. Bigelow is offering services as a next generation crewed space complex that will support missions from vehicles bringing people to spend time in orbit, in specially-designed inflatable habitats. Bigelow currently has two prototype vehicles in orbit, with construction of their first space station expected in 2014 and anticipated availability for client use in 2015.⁷

Beyond Earth orbit, the Google Lunar X-Prize is offering a total of \$30 million to the first companies that can send a robot to the Moon to perform specific tasks, including sending video from the surface back to Earth.⁸ With nearly 30 teams competing from 17 countries, this is the first commercial race to the Moon.

Currently, the FAA does not have authority over commercial missions on orbit, as current regulatory authority ends after the last maneuver associated with launch, and begins again with the preparation for the first maneuver for a reentry. However, through the Commercial Space Transportation Center of Excellence, AST is benefitting from research in the various aspects of space traffic management, including space situational awareness, collision avoidance, and space weather. Once the Commercial Spaceflight Technical Center is opened, AST plans to use it to take advantage of this research and other efforts to contemplate potential architectures and develop proposed concepts of operation for future space traffic management.

VIII. INTERNATIONAL COOPERATION

The goals of the AST international outreach program are to promote FAA regulatory practices internationally to facilitate industry operations in multiple countries. Establishing relationships with other countries will also allow the FAA and global partners to address current and future issues including interoperability of

international space transportation. This supports the AST mission statement and 2010 U.S. National Space Policy to promote commercial space regulations internationally.

AST envisions the possibility of safety agreements between international agencies and governments, defining means for equivalent evaluations and regulatory compliance. Similar safety goals between nations would assist governments in vehicle assessments and acceptance, particularly in the case where one nation does not regulate an industry with existing commercial space vehicles. However, at this juncture the U.S. believes that it is too early for any organization to be responsible for developing and implementing safety standards for the whole world. As of now there are nine space launch faring nations, all at different stages of developing their commercial space industries. It has been AST's vision to allow commercial operators as much flexibility as possible to provide the necessary room to grow while maintaining public safety. AST provides guidance and assistance through outreach activities and various discussions with nations interested in developing a regulatory regime for their commercial space industry.

In the future, if necessary, the U.S. could enter into cooperative regulatory agreements. These agreements could be similar to current Bilateral Airworthiness Safety Agreements, or expand to Multi-Lateral agreements between the countries that regulate developed vehicles and an established industry. Similarly, there may be countries with agreements based on spaceport operations for both launch and reentry. A country could host and accept flights of these vehicles into their territory for commercial purposes, although they may lack legal regimes and regulations for commercial space vehicles. Using model law and regulations, similar to those created for the aviation industry,⁹ AST could help many countries develop a regulatory framework to support these types of operations.

IX. CONCLUSION

The expansion of commercially operated space transportation offers new potential for private human space travel, opening a number of new markets, including the support of the International Space Station. In order to accommodate industry expansion and innovation while ensuring safe commercial operations, the

Federal Aviation Administration Office of Commercial Space Transportation will continue to develop regulations designed to ensure public and occupant safety while allowing development and innovation within the commercial space industry.

The process put in place by AST's regulatory body will allow the office to fulfill its mission of ensuring public safety, while maintaining its mission to encourage, facilitate, and promote a very promising commercial space industry. This mission has been successfully implemented and is supported by the commercial entities that must adhere to its requirements as it provides a progressive approach for regulating this developing industry.

It is the hope of the Office of Commercial Space Transportation that the international community will adopt a similar approach so as to allow the fledgling commercial space industry to mature into a viable transportation business that will benefit all of humanity.

¹ http://www.faa.gov/news/updates/media/Economic%20Impact%20Study%20September%202010_20101026_PS.pdf

² http://www.faa.gov/about/office_org/headquarters_offices/ast/media/PL108-492.pdf

³ 51 USC Chapter 509

⁴ 51 USC Chapter 509

⁵ *FAA & Industry Guide to Type Certification*, http://www.faa.gov/aircraft/air_cert/design_approvals/media/CPI_guide_II.pdf

⁶ <http://www.virgingalactic.com/news/item/virgin-galactic-appoints-its-first-chief-financial-officer/> (July 28, 2011)

⁷ <http://www.bigelow aerospace.com/orbital-complex-construction.php>, May 2011

⁸ <http://www.googlelunarprize.org>, May 2011

⁹ http://www.faa.gov/about/initiatives/iasa/model_aviation/